MECHANICS' MAGAZINE,

AND

REGISTER OF INVENTIONS AND IMPROVEMENTS.

VOLUME III.] FOR THE WEEK ENDING APRIL 19, 1834. [NUMBER 4.

"What justly envied feelings warm the breast
Of him whose ardent soul can find no rest,
But in imparting wisdom's light serene,
And scattering science o'er life's dreary scene."—ANON.

History of Astronomy—its various Systems, &c. [Continued from page 161.]

OF THE MOON.—Next to the sun, the moon is the most remarkable of all the heavenly bodies, and is particularly distinguished by the periodical changes to which figure and light are subject.

The moon is not a primary planet, but a secondary, or *satellite*, which revolves round the earth, and accompanies it in its annual revolution round the sun. The mean time of a revolution of the moon round the earth, or the time between two successive conjunctions, is 29 days 12 hours 44 minutes; but the time she takes to perform a revolution round her orbit is only 27 days 7 hours 43 minutes. The former of these periods is called the *synodical* and the latter the *periodical* revolution. The difference between these periods is occasioned by the motion of the earth in the ecliptic; for while the moon is going round the earth, the earth advances about 29° in the ecliptic, which is nearly one degree per day, and therefore the moon must advance 29° more than a complete revolution round her orbit, before she can overtake the earth, or be again in conjunction with the sun, which will require 2 days 5 hours, her daily motion being about 13 degrees.

Of all the celestial bodies the moon is the nearest to the earth, her mean distance being only 240,000 miles, which is scarcely a four-hundredth part of the sun's distance

from the earth; but her apparent size is nearly equal to that of the sun, she must therefore be a very small body compared with the sun. Her diameter is only about 2,161 miles, and therefore the earth is about 48½ times greater; but the density of the moon is said to be to that of the earth as 5 to 4, consequently the quantity of matter contained in the earth is only about 39 times that contained in the moon.

Although the moon moves over a very considerable portion of her orbit in the course of a day, yet, on account of its smallness, her hourly motion is only about 2,290 miles, which is about one-thirtieth part of the space passed over by the earth in the same time. But in all her motions the moon is subject to great irregularities, which arise from the eccentricity of her orbit, and her proximity to the earth. The eccentricity of her orbit, as determined from the latest and most accurate observations, is 12,960 miles, or nearly one-eighteenth part of her mean distance, of course she is about one-ninth part nearer the earth on some occasions than at others.

PHASES OF THE MOON.

By Thy command the moon as daylight fades,
Lights her broad circle in the deep'ning shades;
Array'd in glory, and enthroned in light,
She breaks the solemn terrors of the night;
Sweetly inconstant in her varying flame,
She changes still, another, yet the same.—[Broome.]

Although the *phases* of the moon are among the most frequently observed phenomena of the heavens, yet they are also among the most wonderful. But on account of the frequency and regularity of the changes in the appearances and situation of this beautiful object, the causes of these phenomena are perhaps less thought of by ordinary observers, than if they were less frequent. The moon being an opaque spherical body, which appears luminous only in consequence of reflecting the light of the sun, can only have that side illuminated which is at any time turned towards the sun, the other side remaining in darkness; and as that part of her can only be seen which is turned towards the earth, it is evident that we must perceive different portions of her illuminated, according to her various positions with respect to the earth and sun.

At the time of conjunction, or when the moon is between the earth and the sun, she is then invisible on the earth, because her enlightened side is then turned towards the sun, and her dark side towards the earth. In a short time after the conjunction, she appears like a fine crescent to the eastward of the sun a little after he sets. This crescent begins to fill up, and the illuminated part to increase, as she advances in her orbit; and when she has performed a fourth part of a revolution, she appears to be half illuminated, and is then said to be in her first quarter. After describing the second quadrant of her orbit, she is then opposite to the sun, and shines with a round illuminated disc, which is called full moon. Her appearance at this time is very accurately represented by the preceding figure.

After the full she begins to decrease gradually as she moves through the other half of her orbit; and when the eastern half of her only is enlightened, she is said to be in her third quarter; thence she continues to decrease until she again disappears at the conjunction, as before.* These various phases plainly demonstrate that the moon does not shine by any light of her own; for if she did, being globular, she would always present a fully illuminated disc like the sun. That the moon is an opaque body, is not only proved from her phases, but also by the occultation of stars, for her body often comes between the earth and a star, and while she is passing it, the star is hid from our view.

MOTIONS OF THE MOON.

The neighboring moon her monthly round
Still ending, still renewing, through mid-heaven,
With borrowed light her countenance triform;†
Hence fills and empties to enlighten th' earth,
And in her pale dominion checks the night.—[Milton.]

It has already been remarked that the motions of the moon are very irregular. The only equable motion she has is her revolution on her axis, which is completed in the space of a month, or the time in which she moves round the earth. This has been determined by the important and curious circumstance, that she always presents the *same face* to the earth, at least with very little variation. But as her motion in her orbit is alternately accelerated and retarded, while that on her axis is uniform, small segments on the east and west sides alternately appear and disappear. This occasions an apparent vibration of the moon backwards and forwards, which is called her *libration* in longitude.

A little more of her disc is also seen towards one pole, and sometimes towards the other, which occasions another waving, or vacillating kind of motion, called the *libration* in latitude. This shows that the axis of the moon is not exactly, though nearly, per-

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* These various phases may be satisfactorily and pleasantly illustrated, by placing a lighted candle on a table to represent the sun, a smaller at some distance from it to represent the earth, and then carrying a smaller white ball round it to represent the moon revolving round the earth.

† Increasing with horns towards the east; decreasing with horns towards the west; and at the *full*.

pendicular to the plane of her orbit; for if the axis of the moon were exactly perpendicular to the plane of her orbit, or if her equator coincided with that plane, we should perceive no other libration than that in longitude.

When the place of the moon is observed every night, it is found that the orbit in which she performs her revolution round the earth is inclined to the ecliptic at an angle of 5° 9′ at a mean rate; this angle is not only subject to some variation, but the very orbit itself is changeable, and does not always preserve the same form: for though it be elliptical, or nearly so, with the earth in one of the foci, yet its eccentricity is subject to some variation, being greater when the line of the *apsides* coincides with that of the *syzygies*, and least when these lines are at right angles to each other. But the eccentricity is always very considerable, and therefore the motion of the moon is very unequal, for like all other planets it is quickest in *perigee* and slowest in *apogee*. At a mean rate, she advances in her orbit 13° 10′ per day, and comes to the meridian about 48 minutes later every day. As the moon's axis is nearly perpendicular to the plane of the ecliptic, she can scarcely have any change of seasons. But what is still more remarkable, one half of the moon has no darkness at all, while the other half has two weeks of light and darkness alternately. For the earth reflects the light of the sun to the moon, in the same manner as the moon does to the earth; therefore, at the time of conjunction, or new moon, one half of the moon will be enlightened by the sun, and the other half by the earth; and at the time of opposition, or full moon, one half of the moon will be enlightened by the sun, but the other half will be in darkness. The earth also exhibits similar phases to the moon to what she does to the earth, but in a reverse order, for when the moon is *full*, the earth is *invisible* to the moon; and when the moon is *new*, the earth will appear to be *full* to the moon, and so on. It has been already mentioned, that the moon always presents the same face to the earth: from hence it is inferred, that one half of the moon can never see the earth at all; whilst from the middle of the other half it is always seen over head, turning round almost thirty times as fast as the moon does.

From the circle which limits our view of the moon, only one half of the earth's side next her is seen, the other half being hid below the horizon of all places on that circle.

To the moon, the earth seems to be the largest body in the universe, for it appears about thirteen times greater than the moon does to the earth.

Of the Harvest Moon.—It has long been known that the moon when full, about the time of harvest, rises for several nights nearly at the time of sun setting; but the cause of this remarkable phenomenon has not been so long known. This appearance was observed by the husbandman long before it was noticed by the astronomer; and on account of its beneficial effects in affording a supply of light immediately after sun-set, at this important season of the year, it is called the *harvest moon*.

In order to conceive the reason of this phenomenon, it must be recollected that the moon is always opposite the sun when she is full, and, of course, in the opposite sign and degree of the zodiac. Now, the sun is in the signs Virgo and Libra in August and September, or the time of harvest; and therefore the moon when full, in these months, is in the signs Pisces and Aries. But that part of the ecliptic in which Pisces and Aries is situated makes a much less angle with the horizon of places that have considerable northern latitude than any other part of the ecliptic, and therefore a greater portion of it rises in any given time than an equal portion at any other part of it. Or, which is the same thing, any given portion of the ecliptic about Pisces and Aries rises in less space of time than an equal portion of it does at any other part. And as the moon's daily motion in her orbit is about 13°, this portion of it will require less time to rise about those signs than an equal portion at any other part of the ecliptic; consequently there will be less difference between the times of the moon's rising when in this part of her orbit than in any other.*

At a mean rate the moon rises 50 minutes later on any evening than she did the preceding evening; but when she is full about the beginning of September, or when she is in that part of her orbit which rises with the signs Pisces and Aries, she rises only about 16 or 17 minutes later than on the preceding evening; consequently she will seem to rise for a few evenings at the same hour.

Although this is the case every time the moon is in this part of her orbit, yet it is little attended to, except when she happens to be *full* at the time, which can only be in August or September.

In some years this phenomenon is much more perceptible than in others, even al-

* It would tend very much to make this phenomenon understood if a terrestrial globe were at hand and rectified for the latitude of London, when reading this description.

though the moon should be full on the same day, or in the same point of her orbit. This is owing to a variation in the angle which the moon's orbit makes with the horizon of the place where the phenomenon is observed. If the moon moved exactly in the ecliptic, this angle would always be the same at the same time of the year. But as the moon's orbit crosses the ecliptic and makes an angle with it of 5° 9′, the angle formed by the moon's orbit and the horizon of any place is not exactly the same as that made by the ecliptic and the horizon. Some years it is greater and others less, even at the same time of the year, for it is subject to considerable variations, owing to the retrograde motion of the moon's *nodes*.*

If the ascending node should happen to be in the first degree of Aries, it is evident that this part of the moon's orbit will rise with the least possible angle, and, of course, any given portion of it will require less time to rise than an equal portion in any other part of the orbit. The most favorable position of the nodes for producing the most beneficial harvest moons, is therefore when the descending node is in the first of Aries, and of course the descending in the first of Libra. When the nodes are in these points 13° of the moon's orbit, about the first of Aries, rises in the space of 16 minutes in the latitude of London, and consequently, when the moon is in this part of her orbit, the time of her rising will differ only 16 minutes from the time she rose on the preceding evening. When the moon is in the opposite part of her orbit, or about the signs Virgo and Libra, which make the greatest angle with the horizon at rising, 13° of her orbit will require 1 h. 15′ to rise, although it were coincident with the ecliptic; and if the nodes be in the points just mentioned, the same portion of the orbit will require 1 h. 20′ to ascend above the horizon of the same place; and so much later will the moon rise every night for several nights when in this part of her orbit. As the moon is full in these signs in the months of March and April, they may be called *vernal full moons.*

Those signs of the ecliptic which rise with the greatest angle, set with the least; and those that rise with the least set with the greatest. Therefore, the vernal full moons differ as much in their times of *rising* every night, as the autumnal or harvest moons differ in the times of their *setting*; and they *set* with as little difference of time as the autumnal ones *rise*, supposing the full moons to happen in opposite points of the moon's orbit, and the nodes to remain in the same points of the ecliptic.

In southern latitudes the harvest moons are just as regular as in the northern, because the seasons are contrary; and those parts of the moon's orbit about Virgo and Libra, where the vernal full moons happen in northern latitudes, (and the *harvest* ones in southern latitudes,) rise at as small an angle at the same degree of *south* latitude, as those about Pisces and Aries in *north* latitude, where the autumnal full moons take place.

At places near the equator this phenomenon does not happen; for every point of the ecliptic, and nearly every point of the moon's orbit, makes the same angle with the *horizon*, both at rising and setting, and therefore equal portions of it will rise and set in equal times.

As the moon's nodes make a complete circuit of the ecliptic in 18 years 225 days, it is evident that when the ascending node is in the first of Aries at any given time, the descending one must be in the same point about 9 years 112 days afterwards; consequently there will be a regular interval of about 9½ years between the *most* beneficial and *least* beneficial harvest moons.

Apparent Size of the Moon.—It has been already remarked, at page 225, that the apparent size of the moon is nearly equal to that of the sun; but the apparent size of the moon is not always the same, for she is often much nearer the earth at one time than another; hence it is evident her apparent magnitude must vary, and that it will be greatest when she is nearest the earth. (See page 225.)

But she appears larger when in the horizon than in the zenith, even on the same evening; and yet it may easily be proved, that she is a semi-diameter of the earth, or about 4000 miles farther from the spectator when she is in the horizon than when she is in the zenith, and consequently ought to appear smaller, which will be found to be really the case if accurately measured.

This apparent increase of magnitude in the *horizontal* moon must therefore be considered as an optical illusion; and may be explained upon the well known principle, that the eye in judging of distant objects is entirely guided by the previous knowledge which the mind has acquired of the intervening objects. Hence arise the enormous estimates we make of the size of distant objects at sea, of objects below us when viewed from great heights, and of objects highly

* The *nodes*, or points where the moon's orbit crosses the ecliptic, move backward about 19° in a year, by which means they move round the ecliptic in 18 years 225 days.

elevated when viewed from below. Now, when the moon is near the zenith, she is seen precisely in this last situation : of course there is nothing near her, or that can be seen at the same time, with which her size can be compared ; but the *horizontal* moon may be compared with a number of objects whose magnitude is previously known.

That the moon appears under no greater an angle, or is not larger, in the horizon than when she is on the meridian, may be proved by the following simple experiment:

Take a large sheet of paper and roll it up in the form of a tube, of such width as just to include the whole of the moon when she rises; then tie a thread round it to keep it exactly of the same size, and when the moon comes to the meridian, where she will appear to the naked eye to be much less, look at her again through the same tube, and she will fill it as completely as she did before.

When the moon is full and in the horizon, she appears of an *oval* form, with her longest diameter parallel to the horizon. This appearance is occasioned by the refraction of the atmosphere, which is always greatest at the horizon, consequently the lower limb or edge must be more refracted than the upper edge, and therefore these two edges will appear to be brought nearer each other, or the vertical diameter will appear to be shortened ; and as the horizontal diameter is very little affected by the refraction, she must appear to have somewhat of an oval shape. The sun is affected in the same manner when in the horizon.

SPOTS, MOUNTAINS, &C. IN THE MOON.

Turn'd to the sun direct, her spotted disc
Shows mountains rise, umbrageous dales descend,
And caverns deep, as optic tube describes.
[Thomson.]

When the moon is viewed through a good telescope, her surface appears to be diversified with hills and valleys ; but this is most discernible when she is observed a few nights after the Change or Opposition, for when she is either *horned* or *gibbous*, the edge about the confines of the illuminated part is jagged and uneven.

Many celebrated astronomers have delineated maps of the face of the moon ; but the most celebrated are those of Hevelius, Grimaldi, Riccioli, and Cassini, in which the appearance of the moon is represented in its different states, from *new to full, and from full to new.*

The plate which we have given at page 225, represents the face of the moon as viewed by the most powerful telescopes, the light or illuminated parts being elevated tracts, some of which rise into very high mountains, while the dark parts appear to be perfectly smooth and level. This apparent smoothness in the faint parts naturally led astronomers to conclude that they were immense collections of water, and the names given to them by some celebrated astronomers are founded on this supposition. For Hevelius distinguished them by giving them the names of the seas on the earth ; while he distinguished the bright parts by the names of the countries and islands on the earth. But Riccioli and Langreni distinguished both the dark and light spots by giving them the names of celebrated astronomers and mathematicians, which is now the general manner of distinguishing them.

That the spots which are taken for mountains and valleys are really such is evident from their *shadows.* For in all situations in which the moon is seen from the earth, the elevated parts are constantly found to cast a triangular shadow in a direction from the sun ; and on the contrary, the cavities are always dark on the side next the sun, and illuminated on the opposite side, which is quite conformable to what we observe of hills and valleys on the earth. As the tops of these mountains are considerably elevated above the other parts of the surface, they are often illuminated when they are at a considerable distance from the line which separates the enlightened from the unenlightened part of the disc, and by this means afford us a method of even determining their height.

Previous to the time of Dr. Herschel, some of the lunar mountains were considered to be double the height of any on the earth ; but by the observations of that celebrated astronomer, their height is considerably reduced.

For after measuring many of the most conspicuous prominences, he says, "From these observations I believe it is evident, that the height of the lunar mountains is in general overrated ; and that when we have excepted a few, the generality do not exceed half a mile in their perpendicular elevation."

As the moon's surface is diversified by mountains and valleys as well as the earth, some modern astronomers say they have discovered a still greater similarity ; namely, that some of these are really volcanoes, emitting fire, as those on the earth do. An appearance of this kind was discovered by Don Ulloa, in an eclipse of the sun, which happened on the 24th of June, 1778. It was a small bright spot, like a star near the margin of the moon, which he supposed at that time to be a hole, or valley, which permitted the sun's light to shine through it. Succeeding observations have, however, led

astronomers to believe that appearances of this kind are occasioned by the eruption of volcanic fire. Dr. Herschel, in particular, has observed several eruptions of this kind, the last of which he has described in the Philosophical Transactions for 1787, as follows: "On April the 19th, at 10 h. 6 m., I perceived three volcanoes in different places of the dark part of the new moon. Two of them are either already nearly extinct, or otherwise in a state of going to break out, which perhaps may be decided next lunation. The third shows an actual eruption of fire or luminous matter. Its light is much brighter than the nucleus of the comet which M. Mechain discovered at Paris on the 10th of this month." The following night the Doctor found it burned with greater violence; and by measurement he found that the shining or burning matter must be more than three miles in diameter, of an irregular round figure, and very sharply defined about the edges. The other two volcanoes resembled large faint nebulæ, which appeared to be gradually brighter towards the middle, but no well defined luminous spot could be discovered in them. Dr. Herschel adds, "the appearance of what I have called the actual fire or eruption of a volcano exactly resembles a small piece of burning charcoal when it is covered by a very thin coat of white ashes, which frequently adhere to it when it has been some time ignited; and it had a degree of brightness about as strong as that with which a coal would be seen to glow in fair day-light."

The appearance which Dr. Herschel here describes so minutely was also observed at the Royal Observatory of Paris about six days before, by Dominic Nouet, like a star of the sixth magnitude, the brightness of which occasionally increased by flashes. Other astronomers also saw the same thing, for M. De Villeneuve observed it on the 22d of May, 1787. This volcano is situated in the north-east part of the moon, about 3′ from her edge, towards the spot called Helicon. After considering all the circumstances respecting these appearances which have just been mentioned, we must subscribe to Dr. Herschel's opinion, that volcanoes exist in the moon as well as the earth.

It has long been a disputed point among astronomers, whether or not the moon is surrounded by an atmosphere. Those who deny that she is, say that the moon always appears with the same brightness when our atmosphere is clear; which could not be the case if she were surrounded by an atmosphere like ours, so variable in density, and so often obscured by clouds and vapors.

A second argument is, that when the moon approaches a star, before she passes between it and the earth, the star neither alters its color nor its situations, which would be the case if the moon had an atmosphere, on account of the refraction, which would both alter the color of the star, and also make it appear to change its place.

A third argument is, that as there are no seas or lakes in the moon, there is, therefore, no atmosphere, as there is no water to be raised up into vapor. But those who contend that the moon is surrounded by an atmosphere, deny that she always appears of the same brightness, even when our atmosphere appears equally clear. Instances of the contrary are mentioned by Hevelius and some other astronomers, but it is unnecessary to take any further notice of them here. In the case of total eclipses of the moon, it is well known that she exhibits very different appearances, which it is supposed are owing to changes in the state of her atmosphere. It is remarked by Dr. Long, that Newton has shown that the weight of any body on the moon is but a third part of the weight of what the same body would be on the earth, from which he concludes that the atmosphere of the moon is only one third part as dense as that of the earth, and therefore it is impossible to produce any sensible refraction on the light of a fixed star which may pass through it. Other astronomers assert that they have observed such a refraction; and that Jupiter, Saturn, and the fixed stars, had their circular figures changed into an elliptical one, on these occasions. But although the moon be surrounded by an atmosphere of the same nature as that which surrounds the earth, and to extend as far from her surface, yet no such effect as a gradual diminution of the light of a fixed star could be occasioned by it, at least none that could be observed by a spectator on the earth. For at the height of 44 miles our atmosphere is so rare, that it is incapable of refracting the rays of light: now this height is only the 180th part of the earth's diameter; but as clouds are never observed higher than 4 miles, it therefore follows that the obscure part of our atmosphere is about the 2000th part of the earth's diameter, and if the moon's apparent diameter be divided by this number, it will give the angle under which the obscure part of her atmosphere will be seen from the earth, which is not quite one second, a space passed over by the moon in less than two seconds of time. It can, therefore, scarcely be expected that any obscuration of a star could be observed in so short a time, although it do take place.

As to the argument against a lunar atmosphere, drawn from the conclusion that there are no seas or lakes in the moon, it proves nothing, because it is not positively known whether there is any *water* in the moon or not.

The question of a lunar atmosphere seems to be at last settled by the numerous and accurate observations of the celebrated astronomers Shroeter and Piazzi, who have proved as convincingly as the nature of the subject seems to allow, that the moon has really an atmosphere, though much less dense than ours, and scarcely exceeding in height some of the lunar mountains.

It is remarked by Dr. Brewster, "The mountain scenery of the moon bears a stronger resemblance to the lowering sublimity, and terrific ruggedness of the Alpine regions, than to the tamer inequalities of less elevated countries. Huge masses of rock rise at once from the plains, and raise their peaked summits to an immense height in the air, while projecting crags spring from their rugged flanks, and threatening the valleys below seem to bid defiance to the laws of gravitation. Around the base of these frightful eminences, are strewed numerous, loose, and unconnected fragments, which time seems to have detached from their parent mass, and when we examine the rents and ravines which accompany the overhanging cliffs, we expect every moment that they are to be torn from their base, and that the process of destructive separation which we had only contemplated in its effects, is about to be exhibited before us in tremendous reality. The mountains called the Appenines, which traverse a portion of the moon's disc from north-east to south-west, rise with a precipitous and craggy front from the level of the *Mare* Imbrum. In some places their perpendicular elevation is above four miles; and though they often descend to a much lower level, they present an inaccessible barrier to the north-east, while on the south-west they sink in gentle declivity to the plains."

The caverns which are observed on the moon's surface are no less remarkable than the rocks and mountains, some of them being three or four miles deep, and forty in diameter. A high angular ridge of rocks, marked with lofty peaks and little cavities, generally encircles them, an insulated mountain frequently rises in their centre, and sometimes they contain smaller cavities of the same nature with themselves. These hollows are most numerous in the south-west part of the moon, and it is from this cause that this part of the moon is more brilliant than any other part of her disc. The mountainous ridges which encircle the cavities reflect the greatest quantity of light; and from their lying in every possible direction, they appear, near the time of full moon, like a number of brilliant radiations issuing from the small spot called Tycho.

It is difficult to explain with any degree of probability the formation of these immense cavities; it is highly probable that the earth would assume the same figure if all the seas and lakes were removed; and that the lunar cavities are either intended for the reception of water, or that they are the beds of lakes and seas, which have formerly existed in the moon.

The circumstance of there being no water in the moon affords a strong proof of the truth of this theory.

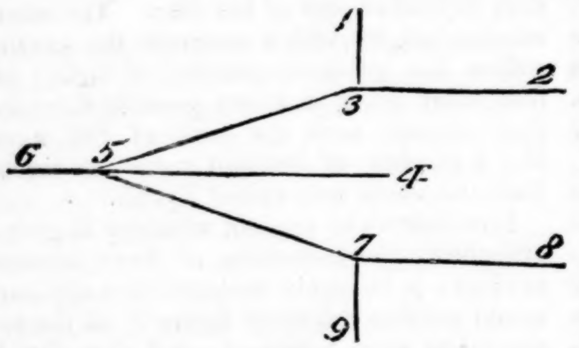
On the Currents of the Ocean. By G. K. O.

To the Editor of the Mechanics' Magazine, and Register of Inventions and Improvements.

Sir,—I have lately read the dissertation on the Oceanic Currents, in your last Number, and am induced to think the author in error as to their cause. If, according to his hypothesis, the earth received a *sudden* impulse, causing it to revolve, (I suppose of course at the same rate it now does,) and leave the waters nearly stationary, they would have appeared to a spectator at the equator to move with the velocity of 1000 miles an hour. This would continually decrease, and at length become imperceptible, on account of friction against the bottom and adjacent particles. But the time that has elapsed since the earth received its first impulse has not been sufficient to produce this effect, or so far as we are acquainted with the subject, even a similar one. Undoubtedly the cause as well as the consequence is permanent and continued, and is, I conceive, easily assigned.

The torrid zone receives more heat from the sun than any like extent of the earth's surface; consequently, its air is heated more than any other—is of less specific gravity than the cooler air of the temperate zones, and of course rises to the higher parts of the atmosphere, being forced up by the air that comes in to supply its place. This would produce a direct motion from north to south towards the equator in the directions 1–3 and 9–7.

Now, the surface of the earth, at the latitude of 45 degrees, revolves about the rate of 700 miles an hour, and if the air of that region were suddenly transferred to the equator, it would apparently move from east to west at the rate of 300 miles an hour in the direction



4–5, but as the transfer is gradual, it would receive velocity from the earth in its passage over it, and therefore its apparent velocity at the equator would be comparatively small if contrasted with the difference of velocities at 45 and 0 degrees.

We have now the two motions 3–2 and 1–2, which, being compounded, will produce the single motion 3–5. Two streams of air from the north-east and south-east, represented by 3–5 and 7–5 meet at the point 5; their opposite forces, 1–3 and 9–7, being equal, will be destroyed, and the remaining forces 2–3 and 8–7 will continue in the direction 5–6.

This, then, is the reason why, near the equator, the wind blows from east to west, and north and south of it from north-east and south-east. The air is here, for simplicity, represented as moving in straight lines; but it really moves in curves, and the line of direct motion from east to west is a few degrees north of the equator.

If we suppose the waters of the torrid zone much exposed to the heat of the sun, aided by the dry winds from the land, evaporation will proceed rapidly. Of course, then, the waters at the equator would be relatively lower than those of the other parts of the earth, which would therefore flow toward the equator, and take a westerly course, for the same reason that the air does, subject however to more modification, interruption, and counter currents, inasmuch as it meets with more impediments. I think the currents round the Capes and in the Indian Ocean are perfectly explicable on this hypothesis (theory ?), and I might enter into detail if circumstances permitted.

Yours, &c. G. K. O.

April 17, 1834.

Ericsson's Caloric Engine. By G. K. O. To the Editor of the Mechanics' Magazine.

Sir,—After reading several times the description of Ericsson's Caloric Engine, contained in your February number, I am yet at a loss in regard to some things. Assuming, as the description does, that the air in the part of the engine represented black is under greater pressure than that in the white, but being of nearly the same temperature, it must be of greater density; for example, let the density of one be represented by 50, and that of the other by 100, that is, the quantity of air contained in any given portion of the black is twice that contained in a corresponding portion of the white part: suppose the temperature in the large cylinder is 480 degrees higher than that in the small one. Now, if 10 cubic feet of air of the density of 100 be admitted into that of 50, it will expand till it becomes of the same density as that into which it is admitted, and occupy nearly 20 cubic feet; and when reduced 480 degrees in temperature, will yet occupy 10 feet. While the large cylinder admits 10 feet of the density of 100, the small one takes out 5 feet of the density of 50, which, though expanded by the heat, would only fill 10 feet of the density of 50; but being admitted into the black part, where the pressure and density is 100, it will become of the same density, and, of course, occupy but 5 feet. If the case be as I have stated, the corresponding portions of the two bodies of air in the black and white parts will soon be brought to the same density by a few strokes of the engine, and (according to the description) the *difference* of density constitutes the motive power. Will you, or some of your correspondents, please explain this difficulty. Yours, &c. G. K. O.

Locomotive Steam Engine.—I send you a brief statement of the performance of a locomotive steam engine, recently built under my direction by Mr. Baldwin, of Philadelphia, and now running on the Charleston and Hamburg Railroad. She started from Aiken, 120 miles from Charleston, on Thursday morning last, at 15 minutes past 7 o'clock, with 11 cars loaded with cotton; at Blackville, 90 miles from Charleston, another load was added; at Midway, 72 miles from Charleston, 2 others were added; and at Branchville, 62 miles from Charleston, a fourth load was added—making in all a train of 15 loaded cars. This immense weight, not less than 80 tons, including engine and tender, was delivered in Charleston, at 7 o'clock 15 minutes, in the evening of the same day, notwithstanding delays on the road, at the different stations, of 4½ hours—making the running time 7½ hours only, for the distance of 120 miles. Numerous ascents of 20 to 35 feet per mile were overcome with this load; and what is of most importance to those interested in railroads, is, that the greatest weight on either wheel of the engine does not exceed 1½ tons. Respectfully, yours,

E. L. Miller.

New Invented Stomach Pump—*Description of a New Form of the Stomach Pump.* By P. B. Goddard, M. D., of Philadelphia. [From the Journal of the Franklin Institute.]

This pump consists of two parts, one of which I shall call the valve box, the other is an ordinary syringe, of good construction, to which the valve box is screwed when in use.

The valve box is a cylinder of metal, containing ovoidal or egg-shaped cavities, equally distant from the centre of the cylinder; at this point a pipe enters, which, when screwed on to the syringe, opens a communication between its cavity and these two cavities in the valve box. Near each end of the cylinder a short and slightly conical tube projects laterally, to which a flexible tube is to be fastened, and which causes a communication between the flexible tube and the cavity in the valve box. Each of these cavities contains a bullet accurately turned, so as to fit the orifices of the tubes, entering into it, and acting as a valve. It will be seen by reference to the accompanying cut (which is a section of the valve box) that if the valve box be held vertically, and the syringe screwed on it, the bullet in the upper cavity will fall upon the orifice of communication between it and the body of the syringe, whilst the bullet in the lower cavity will, in like manner, lie upon the orifice of the tube leading externally. If the lower tube be now immersed in water, and the piston of the syringe be drawn out, it will be evident that the body of the syringe will be filled with water from the lower tube. If now the piston be pressed home, the water will pass out of the upper tube; the bullet in the lower cavity preventing its escape there, just as the bullet in the upper one prevented the entrance of air before. It will then always pump water, or any other fluid, from the lower tube to the upper.

If the position of the valve box be now reversed, and the end which was above be placed below, the bullets will fall by their own gravity into the opposite ends of the cavities, and the instrument will act as it did before, viz. pumping from the lower orifice to the upper, although the relative position of the tubes has been reversed.

To use this instrument, the valve box must be held in nearly a vertical direction. A long flexible tube being passed into the stomach, is attached to one of the short conical tubes, say the upper, and a short tube leading to a basin is then fastened to the lower one. The basin being filled with warm water, and the syringe put in action, the water will pass into the stomach and dilute the poison. When enough has passed in, the syringe is to be turned in the hand, so as to bring the tube down which was before above, without taking off the flexible tubes, or changing them in any way, and the syringe again put into action. The water will be pumped out of the stomach, bringing the poison along with it.

The following are the chief advantages of this instrument. It is perfectly simple in its construction, and not liable to get out of order.

The directions for its use are easily understood, aud as easily remembered.

After the flexible tubes are once adjusted, no alteration is required until the operation is finished.

When the instrument is once put in action, gallons of water may in a few minutes be passed through the stomach, thus washing away every trace of poison and saving many a valuable life.

Fig. 1, section of valve box—*a a*, cavities for the bullets—*b b*, bullet valves—*c c*, tubes, to which are attached the flexible pipes—*d*, female screw to attach it to the syringe

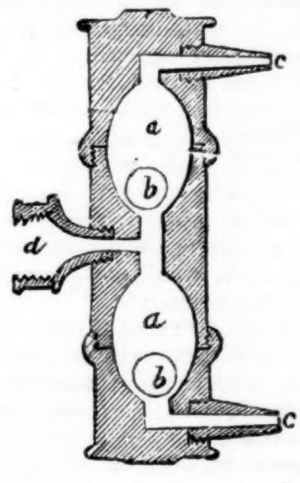
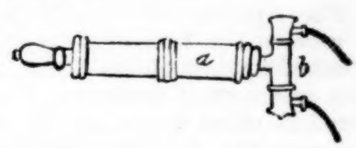


Fig. 2, the entire instrument—*a*, the syringe—*b*, the valve box.



American Patent—*Specification of a Patent for Improvements in the Wheels of Railroad Carriages. Granted to* John Elgar, *Civil Engineer, City of Philadelphia, November* 19, 1833.

To all whom it may concern, be it known, that I, John Elgar, Civil Engineer of the city of Philadelphia, have invented certain improvements in the wheels of railroad carriages, by one of which improvements they are made to adapt themselves more readily to curved roads

than such as have been heretofore used for that purpose; and by the other a construction is given to them which will render them more firm and durable than those now in general use; and I do declare that the following is a full and exact description of my said improvements.

The self-adjusting conical wheel for running upon curved roads is well known to engineers, it having been made the subject of a patent by Mr. James Wright, and a modified form of it being now used on the Baltimore and Ohio railroad. The plan which I have devised is a new modification of this principle, by which some of the inconveniences which have hitherto attended its employment are in a great degree, if not altogether, obviated.

Instead of making the wheel conical on its whole tread, like Wright's, or of forming the conical part against the flanch, and leaving the other part cylindrical, as in those used on the Baltimore road, I form the cone on the outer part of the tread of the wheel, opposite to the flanch, leaving that part of the tread which extends from the flanch towards the opposite side cylindrical, or nearly so, for one half of its width, more or less, and then tapering outwards in such degree as may be most convenient, according to the curvature of that part of the road which has the smallest radius.

The curved part of the road is adapted to these wheels, by widening the track in proportion to the radius of curvature, so as to admit the conical part to roll on the interior rail, whilst the cylindrical part bears upon the exterior rail. This construction obviates the objection arising from the wrong tendency of the cone when running on the exterior rail, and adapts the whole more perfectly to those parts of the road which are straight, and produces other advantages, which will readily occur to experienced engineers.

In order to render railroad wheels more firm and durable than those now in use, I form that part of the wheel usually occupied by the spokes of two plates of iron, preferring for this purpose thick sheet iron of three eighths of an inch, more or less, in thickness. These sheets of iron are raised so as to be concave, or dishing, forming the segments of a large sphere, or, if preferred, they may be made conical. These plates have a hole in their centres to receive the hub, or nave, and have a flanch turned up, over which the hoop of the hub may pass; or, if preferred, the hub may be secured in other ways. If the rim or tire is of wrought iron, the plates may have a flanch turned at their peripheries, through which they may be rivetted on the interior of the rim. When the rim is of cast iron, the plates may be secured without a flanch, one being cast within the rim, on either side, against which the plates may fit, rivets or bolts passing through them and through the flanch, to secure them in their places. Other modes of fixing the plates in their places may be devised, and I do not mean to confine myself to any specific plan of effecting this object, the manner of doing so not in any way affecting the principle upon which my improvement is founded. This mode of construction is particularly adapted to wheels for locomotive engines, that run either on common roads or on railways.

What I claim as my invention in my first described improvement, is the making the wheel of a railway carriage conical on its outer edge, and cylindrical between said conical part and the flanch, for the purpose of adapting it to run upon curved roads, and applying it thereto upon the principle, and in the manner herein before set forth.

What I claim as my invention in my second described improvement, is the substituting of metallic plates (generally of wrought iron,) for the spokes usually employed; and the giving to such plates a form which shall be convex, either curved or conical, from the rim to the hub of the wheel. JOHN ELGAR.

IMPORTANT DISCOVERY.—We are informed by two gentlemen who lately passed through Syracuse, N. Y., that Mr. Avery, the proprietor of an extensive iron foundry in that place, has made a very important discovery in relation to casting of iron. The best kind of earth used in foundries is brought we believe from Canada. Mr. Avery analyzed this earth, and found it to contain a certain portion of blue clay. Following this up by a series of experiments, he discovered that if *common fine sand* was mixed with *common blue clay*, in the proportion of one tenth part of clay to nine tenths of sand, it would constitute the best possible composition for casting that he had ever used. Even the most delicate castings came out perfectly free of sand, and required no sort of cleaning by vitriol. He dismissed ten of his cleaners on the spot. Mr. Avery has taken out a patent for his discovery, and estimates that his composition will make an immense saving in the expense of iron foundries—in the diminution of labor, the cheapness of the sand, and in the disuse of vitriol in the process of cleansing. We hope that our neighbors of the furnace will immediately test it by experiment.—[Brattleboro' Independent Inq.]

STRAW WEAVING.—We had the pleasure, a few days since, of witnessing the operation of weaving straw for the manufacture of bonnets, at the establishment in this town, under the direction of Mr. J. P. Golding. There are now employed in this establishment upwards of 100 females, all engaged in weaving the straw into plaits or webs of about two inches in width. The variety of patterns is large, many of them very beautiful. In some the common rye sraw of this country is interwoven with the Tuscan straw. The web or warp into which the straw is woven is composed of silk doubled and twisted from the cocoons very fine, but yet sufficiently strong for the purpose. This silk is prepared, as we are informed by Mr. G., by a son of his, who is located in Mansfield, Conn. where for several years past a considerable quantity of silk has been produced. Mr. Golding was formerly a silk weaver in Manchester

England, and his family understood the culture of the worm, the manufacture and weaving of silk, and are said to be in the exclusive possession of this information in this country. Mr. Golding has already invented machinery and woven several patterns of silk vesting and webbing in this country, but at present this part of the business cannot be profitably carried on here. He intends, however, to prosecute the business, and has set out trees for that purpose at Dedham.

We have no doubt that the production and manufacture of silk will become a very important branch of American industry, as many millions of dollars are annually paid for the imported article. We have yet much to learn, but a few years will put the country in full possession of all the necessary information for carrying on successfully every branch of silk manufacture.

We notice by the papers that some silk handkerchiefs have been manufacturad in Dayton, Ohio, under the superintendence of Daniel Roe, Esq. the produce of the native mulberry. Their color is the natural color of the silk, and they appear to be a very durable article.—[Bunker Hill Aurora.]

Fanning Mill.—An ingenious wight, named William Gall, has constructed a pair of self-acting fanners, which, without the aid of man, sift wheat, corn, &c. The simplicity of the invention is astonishing. By a funnel of sheet-iron, the wheat descends upon an iron wheel full of brackets; the wheel is so nicely balanced, that the moment the wheat falls the wheel revolves, and throws the wheat into a pair of fanners on the flat below. On the outside of the iron wheel is a wooden one, and over it is a belt attached to the fly wheel of the fanners, which impels them, and so long as a particle of wheat is left, the machine moves and throws it out.—[Sat. Eve. Post.]

Nautical Schools.—[*From the Annals of Education.*]—Dear Sir: Amid all the interesting matter touching the cause of education, with which your pages abound, I do not remember to have seen any article on the particular subject of *nautical education.*

It is undoubtedly true that the importance of education in its fullest acceptation, and more especially elementary education, is not duly appreciated by any community on earth—I mean, if we are to judge of the views of mankind by their every day practice. It is however no less true that public attention, in many parts of our country, has been more directly turned to this subject of late, and that great efforts have been made, and are still making, to wake up the benevolent, the enlightened, the patriotic, and the Christian, to the immense and paramount importance of an increased education of the people, who are to decide the destinies of this immense and growing republic. But in looking at a subject in its general bearings and relations, we often lose sight of its particular divisions and the relative importance of its various parts. It has thus happened, probably, that the education of seamen, as a class, has attracted but little attention and interest.

The time was, when all the claims of seamen were dreadfully neglected—when they were used only like the vessels they manned, and the sails they unfurled to the breeze or reefed in the gale, to bear the cargoes of their employers to foreign lands, and return with the produce of other countries to enrich their owners. Under such a state of things, what could be expected of seamen, exiled from society, for the greater part of the time, exposed to hardships and perils unknown to landsmen, with no guide but their passions? Is it surprising, that when released from the temporary restraints of their captains, and from the duties of the ship, they should riot in vice and misery?

Such was the history of seamen, to a lamentable extent, at home and abroad. *At home,* they felt like strangers and outcasts, and were welcomed to no society but that which would enervate their bodies, and pollute and destroy their souls—filch their money, and debase and paralyze all the finer feelings of their nature. *Abroad,* they were induced to seek the vicious indulgences to which they had been trained at home.

But the scene is now changed. American seamen, at least, are beginning to be regarded as men—as immortal—as having rights and immunities, sacred and valuable. Those who have hitherto fattened on their misery, have begun to tremble.

Their claims are heard—thought of—respected; their wants, in a measure, provided for—their morals considered and guarded. Hence we see *Bethels* arising all through the land in our cities, where they may meet to worship God—*Boarding Houses,* where they can resort in safety, and be free from temptation—*Savings Banks,* where they may lay aside their earnings, to provide against age, sickness, and want, instead of ministering to their appetites and vicious propensities; and hence we hope to see *Seminaries* intended and adapted for their instruction in common branches of education, and in nautical science.

I am aware that one or two such schools have been established, and that more are contemplated; but it is highly desirable to call the attention of the public generally to this subject, and to impress them with the importance and the expediency of establishing many such institutions.

It would be unnecessary to detain your readers by any remarks as to the importance of education in the common branches, to any individuals in the community. But I will say that seamen need such instruction especially, and that they are in peculiar danger of being overlooked.

They need it especially. If they are untaught when they go to sea, as too many of them are, pride and shame will tend to keep them ignorant. If they cannot read or write, how many hours at sea will be wasted, that might else be profitably employed! Their minds will be stored with vice and profanity, for lack

of better instruction. But the evil does not stop here. If they are ignorant of the rudiments of knowledge, they cannot learn navigation as a science; and are shut out from all hope of rising above the rank of a common sailor.

They are in peculiar danger of being overlooked. Most seamen go to sea when they are young, and of course, if not early instructed, they are left entirely to themselves for life. Others, of their age, may be also neglected in youth; but change of place, or circumstances, may favor them with instruction in the family, the store, the familiar lecture, or some association for mutual improvement.

Some such system as the following might be adopted to advantage.

1. Let merchants and captains give preference to young seamen who can read and write.
2. Let a nautical school be established in every seaport town in the country; where not only navigation shall be taught at a moderate price to all who desire to be instructed, but connected with which shall be a master devoted to teaching elementary branches of common education.
3. Let merchants, and others interested in seamen, recommend to their crews to resort to these schools, and perhaps pay a bounty to such seamen as bring certificates of proficiency from the instructor.

Should you deem the subject suitable to your work, I shall be happy to furnish you with some remarks from one who has had experience in conducting a nautical school.

A Friend to Seamen.

Internal Improvements, No. V. By F. To the Editor of the American Railroad Journal, and Advocate of Internal Improvements.

Sir,—Animated discussions have at various times taken place, in relation to the particular plan that is best adapted as a general means to promote and facilitate internal commerce; and although systems have been explained, and theories investigated, in the most lucid and elaborate manner, they have been too frequently characterized by party influence, to produce any other effect than that of exciting animosities to the prejudice of the true interest of the cause.

It is not believed that any one particular plan can with propriety be recommended as most fit to subserve the general interest of the country. The circumstances which should govern the mind in the choice and adoption of such plan are principally of a local character, and entirely independent of general rules. Canals, railways, turnpikes, have each their particular province, their particular sphere of action. Each, according to circumstances, possesses, relatively, certain capabilities and advantages, for which it claims precedence over the other two; and for which alone it should be selected as most likely to conduce to the improvement of the section of country it may be intended to benefit.

One of the main causes of error, and one that has been productive of more injury than any other, may be traced to the prejudice that has so unreasonably existed in the minds of the people, against the employment of men of science in the construction of important public works. It is disgraceful to find the interests of men of this class, even when possessing a large share of practical knowledge, prejudiced by the very thing which ought, in the eyes of an enlightened community, to have advanced them; to find their services slighted and put aside, to give place to those who, professing to act independently of all theory and scientific principle, and ignorant of every thing except the few practical rules indispensable in their vocations, happen to enjoy the unenviable distinction of being mere practical men. It is only by the lights of science that we can ever hope to estimate with any degree of accuracy the combined actions of different causes, and by a correct knowledge of its principles that we can avoid making improper applications of established laws, and be enabled to draw legitimate conclusions from particular premises. It is not imagined by any reflecting person that knowledge of this kind can possibly militate against a correct conception of plans, and a judicious arrangement of details. Were it reasonable to suppose, even for a moment, the encouragement of any such ridiculous notions, many convincing instances might be adduced as evidence to maintain the contrary position,—that without its assistance no engineer can hope to attain to eminence in his profession. Prony, Tredgold, and Smeaton, were all, in some sense, practical men; but to an extensive practice they united a profound knowledge of all the different branches of mechanical science; and who have contributed more than they to the general diffusion of knowledge, under the different heads to which their attention was directed. We are persuaded that it is only from the exertions of such men (and many such may be found in this country), that we can possibly escape falling into the snares that are laid by designing men to dupe the unwary.

So much has already been written on the relative value of railroads and canals, that the subject is indeed well nigh exhausted; and although little or nothing, it is believed, can be adduced further to strengthen our position, but what has been hundreds of times reiterated from every quarter of the Union, still it cannot be passed by, consistently with the object in view and in justice to the cause we uphold, without a brief notice of some of the characteristics by which these formidable rivals, if such they must be considered, are chiefly governed. That of friction, as it has proved a fruitful source of disputation among theorists, claims particular attention, as the basis on which most of the arguments are founded; and although the experiments from which our information on this important topic is derived have been conducted with the greatest care and precision, the results differ so widely in character, and present so many material opposing points, that the laws established from the conclusions drawn from the one

have ever been invalidated by those drawn from the other. It was long looked upon as a fundamental principle, that *the friction of rolling and sliding bodies was the same for all velocities*, and consequently, that any body being acted on by a constant force barely sufficient to overcome its friction, together with the resistance of the atmosphere, would, like a falling body acted on by gravitation, proceed with a motion continually accelerated, and increase beyond any assignable limit. However startling this assertion may have been at its first appearance, it yet found many to countenance its introduction, and claim its admission as a truth deserving unlimited credit. Here was a fine field for speculation; and to this apparent paradox may be traced the fountain head from which has emanated all the enthusiastic hopes and extravagant expectations which have characterized the railroad mania during the last few years. Fortunately, however, for the cause of science, men have been found sufficiently sceptical to question the truth of this absurd position. Morin, satisfied in his own mind, that his predecessors, Vince and Coulomb, had been laboring under the effect of some undefinable error, determined to sift the matter until he discovered the cause. Having prepared an apparatus for this purpose, he varied the velocity from the lowest up to ten feet per second; the rubbing surfaces from some tenths of a square inch to nearly five hundred square inches; and the pressures from ninety to twenty-five hundred pounds. All the experiments made within these limits, and they were repeated many times, agree in character, and prove, what is more consistent with our ideas, and reconcileable with our experience, that the friction of surfaces moving on each other is ***entirely independent both of velocity and surface, and proportionable to the pressure.*** In this experiment, of course, the opposing resistance of the medium through which the body passes is abstracted.

These practical results were still, however, highly satisfactory, as placing the ability to propel carriages on railroads at a suitable speed, for the more rapid dispatch of business, beyond a doubt; and as showing the striking relative difference in the force requisite to produce the same degree of speed upon canals. But before going further, let us examine a little into the nature of this latter resistance. We find this to be governed by totally different laws: that it increases with the square of the velocity. It is the resistance of the medium through which the body passes, and is occasioned by two causes,—the cohesion of the particles and the inertia of matter. Thus, if a body move through a fluid at different velocities, the resistance will increase with the increased number of particles struck in a given time; which, of course, will be determined by the space run through in that time. If, therefore, a triple number of particles be struck, the resistance will be triple; but it increases further with the force with which the body strikes the particles, and this being proportional will be also at a triple rate, making the whole resistance nine-fold: i. e., partly in the ratio of the velocity, and partly in the duplicate ratio of that velocity.

The only apology offered for these tedious and uninteresting details, is the circumstance of their being addressed to the unenlightened—to those whose occupations may preclude them from bestowing much care and reflection upon subjects of this character. It is a desideratum admitted by all who have the interest of the country at heart, that a correct knowledge of fundamental principles be so generally diffused throughout every class of society, that each and every individual member thereof may be enabled of himself to pass judgment on the relative merits and demerits of the various schemes presented for public approbation; and to detect the fallacies of those whose wilful misrepresentations have so often before led into error. Almost every instance that has occurred where serious injury has resulted from ill-advised and ill-concerted undertakings, has been characterized by a total ignorance of the commonest rules of hydro-dynamics. Many unhappy examples might be adduced to illustrate this observation, but we forbear, in the hope that the experience derived from the past will so regulate the actions of the future as to render their recurrence, unless wilful, next to impossible.

But to return to our subject. It appears from the different nature of these resistances, that the rate of velocity on canals is confined to a very low limit, whereas the rate of that on railroads may be increased to any height that will not prove injurious to the road and carriage. On the other hand, however, it is to be remarked that this very principle, which is harped on as an insuperable objection to the further use of the canal, actually endows it with advantages that are altogether unattainable on railroads. We shall endeavor to explain this in as few words as possible. The relative good effect produced at different velocities, in round numbers, stands very nearly thus: One to three in favor of canals at a velocity of two and a half miles per hour; equal at a velocity of five miles per hour; and one to three in favor of railroads at a velocity of ten miles per hour. Now, reasoning from these premises, it can be made to appear that a force of traction on a canal equal to one hundred pounds will be amply sufficient to move a mass equal to ninety thousand pounds. A horse travelling at the slow rate of two miles per hour can draw with ease thirty tons in a boat weighing fifteen tons. This gives us at once a proportion of one to nine hundred as the amount of resistance opposed to the motion of a vessel through the water at two miles per hour. Now, reducing this velocity to one mile per hour, the proportion becomes one to three hundred and sixty; and if to a half a mile per hour, one to fourteen hundred and forty; or, in other words, a traction equal in force to 100 lbs. can thus at that rate draw a mass of the enormous weight of 1,444,000 lbs. This as-

tonishing fact does not only exist in theory, but has actually been proved in practice, upon our own lakes. A single horse has been known to draw, at the rate of one mile per hour, a raft weighing two hundred tons. F.

On Railroad Wheels, &c. By Wm. M. Cushman. To the Editor of the Mechanics' Magazine and Register of Inventions and Improvements.

Sir,—There are few applications of science which make such continual and importunate calls upon its resources as the subject of railroads—its principles having place as well in the minute, as the more prominent parts; and to such an extent does this obtain, that, although casuists might dispute the endowment of sensibility, we may with some propriety credit the "sympathy" which subsists among its various constituent parts.

To those of your readers who know the important part the appendage, which forms the subject of this paper, acts in the successful operation of a railroad, no apology for its appearance would be proper or necessary. Impressed, however, with the belief that, in matters of science, nostrums and secrets are the peculiar property of empiricism, I am persuaded that liberality, to a certain extent, among engineers, in a mutual interchange of ideas through public journals devoted to such objects, will be attended with the most beneficial results to the profession and its members generally—it is the hope of contributing a trifle to such result, which induces me to send for publication, the subsequent compilation from my common-place book.

The problem assigning to the parts of the wheel the proportions requisite to sustain a given stress, has been investigated;* but as I have never seen any discussion touching the particular distribution of metal to obtain the requisite strength with *the least quantity of metal, and at the same time to offer the least resistance to motion*, after briefly reciting the mode of proceeding in order to attain the single condition of strength, I propose to examine that necessary to the attainment of the latter conditions.

To determine the dimensions of the rim, arms, &c., consider them rectangular prisms, calculate the stress these prisms will bear; and lastly, dispose them in the best form for strength and motion on the various parts of the line.

Each arm must be of sufficient strength to bear the greatest stress that can ever fall upon it, which is half the weight of the car and its load; then this formula holds,

$$\frac{S}{2200} = a; \ (1.)$$

in which S is put for half the weight, and a for the surface in inches of the section of the arm.

In the rim this formula holds,

$$t = \sqrt{\frac{c \times S}{850\,b}}; \ (2.)$$

in which c = the length of the arc between the arms, *in feet*, at the mean diameter of the rim; S, as before; b = the breadth of the rim, *in inches*; and t = the thickness of the prism, *in inches*—to be disposed in the best form for strength and for the rim. The formula (2) is general, but the other is affected by the number of arms; it is designed for a 3 feet wheel, having 10 arms, or a 5 feet wheel, having 12.

But since, in rolling bodies, *each particle of matter resists motion in proportion to the square of its distance from the axis of motion*, it is evidently an object of the first importance to dispose of the weight of metal as near the axis of motion as is consistent with strength, safety, and the perfection of the wheel in other respects.

To illustrate the effects of this principle, let the weight of a car and its load be 3 tons, and suppose further, that a wheel of 3 feet diameter is the height most suitable for the road it is to run upon. Now, if it be desired to sustain a given *constant* weight by a prism of a given breadth, supported at each extreme, it is manifest that, as the distance between the supports is increased, the depth of such prism must likewise be increased in a certain ratio; and vice versa. This condition is expressed in formula (2,) in its true ratio—hence, in increasing the number of arms, we diminish the weight of the rim, and effect a transfer of metal towards the centre of motion; and this may be done without injury to the wheel in any respect.

I shall in the first place assume formula (1) to be general, to illustrate the effect resulting *solely* from the *change of place of the metal from the exterior towards the interior.*

Excluding the part of the radius occupied by the nave and rim, the quantity of metal for an arm will be 19.92 cubic inches, and on the hypothesis of 10 arms, the surface of a section through the rim will be 4.090 inches; but on the hypothesis of 9 arms, the sectional surface is 4.315 inches: hence the volume of the rim for 10 arms is less than that for 9, by 25.5 cubic inches.

These preliminaries made, in order to effect a comparison of the efficiency of the two wheels:

Let the prism representing the volume of any arm be divided into an *indefinite* number of equal parts, by planes cutting it orthogonally, and m = one of these parts; let also r, r', r'', r''', &c., ad infinitum, be the respective distances of these quantities from the axis of motion, and x = the sum of the rectangles of the subdivisions into the squares of their respective distances from the axis: then, by the law, we get

$$mr^2 + mr'^2 + mr''^2 \text{ \&c. ad inf.} = x;$$

* Vide Tredgold on Railroads. Science is deeply indebted to this author: his work on railroads, however, published in their stinted infancy, although in many particulars sound, is in others behind the age; it has the merit of having been a pioneer—of having deracinated by a rigorous application of scientific principles, the absurdities which at that period entangled the subject. It is in our own country that many of its most important principles have been developed, with a rapidity corresponding with the fertile genius of our countrymen, and the impetus and zeal every object to which they direct their attention receives.

which expression, since each term is affected by the same quantity m, becomes

$$m\,(r^2 + r'^2 + r''^2 \text{ \&c. ad inf.}) = x\,; \quad (3.)$$

In assigning a value comparatively small to m, we shall have for all practical purposes the value of x: thus, let $m = \frac{1}{30}$ of the mass of the arm, which (taking the diameter of the nave 5 inches, and considering the last half inch of the arm merged in the rim,) is represented by 19.92: then, r, r', r'', &c. become 1, 2, 3, ... 36; and,

$$\frac{19.92}{30}(6^2 + 7^2 + 8^2 \ldots \overline{35}) = 9864. = x. \quad (5.)$$

Again, since the matter in the rim lies in a circle described about the axis, it is at every point equally distant from the axis; its mass, therefore, drawn into the square of its distance from the axis, will be its moment of inertia: hence,

$$\overline{36}^2 \times 25.5 = 33048 = x'\,; \quad (6.)$$

wherefore, the *relative resistances to motion of the means used to attain the same end*, in the two wheels, are as

$$x : x' :: 1 : 3.35.$$

2d. But the mass of each arm may, in general, be diminished in the ratio of the increase of number to that contemplated in formula (1,) in consequence of conditions entering therein.

The value of x (form. 5) is reduced by the addition of a single arm, $\frac{1}{9}$ for each arm; their sum being 9, gives x for the total diminution in resistance to motion offered by each, which in amount is just sufficient to make the new arm; whence the relative moments are as

$$x : x + x' :: 1 : 4.35;$$

if the number be increased to 11, the relative moments stand thus,

$$1 : 6.94;$$

if to 12, thus,

$$1 : 9.62;$$

and so on for a greater number.

Such are the results when the principle of momentum of inertia enters as a condition in the determination of the problem.

Extending this principle, we see that the wheel of greatest efficiency with the least quantity of metal would be one without spokes, i. e. having a sheet of metal extending from the nave to the rim: but the limit to the number of arms will be attained when the rim has such a thickness that, when further reduced, there would be danger of fracture from other causes than the stress it is to bear.

I shall not extend my remarks further. By those acquainted with subjects of this nature, the consequences which flow from them will readily be appreciated. My aim has been not to define with precision the exact form necessary in practice, but to illustrate the importance of introducing the principle of momentum of inertia; and to indicate, in a general manner, the changes which ought to be made in the ordinary form, from its introduction.

WM. M. CUSHMAN, C. E.

Albany, April 14, 1834.

Dip, Declination and Variation of the Needle in the United States. By A CITIZEN OF NEW-YORK. [From the Railroad Journal.]

If the manufacturer of compasses in Birmingham, England, will be so polite as to send to Dr. Smith, 28 Water street, New-York, two of his needles, that stand alike in their directive course for three days successively, he will then answer the question put by him in the Railroad Journal, of March 22d, 1834; for he never has seen two needles, which were imported from England, that stand alike for that length of time.

MALT AND TEA.—It is a curious fact, that the consumption of malt in England and Wales has been *stationary* for nearly half a century, though the population has more than doubled during that period. [M'Culloch's Commercial Dictionary, p. 723.] The tables, however, show that the public brewers, since 1787, have contrived to manufacture *one-third more* STRONG *beer out of the same quantity of malt!* So that both the quantity and quality of the national beverage have declined. The consumption of genuine tea has also been steadily declining, compared with the population. The sales of the East India Company show that the average consumption per head of *their* teas in 1801, was 1 lb. 13.6 ounces; in 1831, per head, 1 lb. 9.2 oz. showing a decline of full 17 per cent. during the last thirty years. As the fashion of tea-drinking has certainly not declined, it may be concluded, even after allowing for the increased consumption of coffee, either that the decoction has been made weaker, like beer, or that the shops have sold something else in place of the Chinese plant. The numerous convictions of persons having adulterated tea in possession favor the latter conclusion. Monopoly and high duties have operated unfavorably on public morals. "Lovers of tea or coffee," it is truly remarked, "are rarely drinkers:" and Raynal ascribes the sobriety of the Chinese to the use of these grateful beverages, which produce all the good, without the evil consequences, of more powerful stimulants.—[History of the Middle and Working Classes, second edition.]

THE NUMBER FIVE.—The Chinese have a great regard for this number. According to them there are five elements—water, fire, metals, wood, earth; five perpetual virtues—goodness, justice, honesty, science, and truth; five tastes—sourness, sweetness, bitterness, acidity, and salt; five colors—azure, yellow, flesh-color, white, and black; they say there are five viscera—the liver, the heart. the lungs, the kidneys, and the stomach. They count five organs of the senses—ears, eyes, mouth, nose, and eyebrows. A Chinese author has written a curious dialogue between these senses. The mouth complains that the nose is not only too near, but above her; the nose in reply defends its position, by stating that but for it the mouth would eat stinking meats. The nose in turn complains of being below the eyes; they reply

that but for them men would often break their noses.—[Le Lanterne Magique.]

DR. MAJENDIE'S OBSERVATIONS RESPECTING THE PULSE.—Majendie has given a scale of the pulse, which shows that the difference in frequency between that of the infant and the aged is more than double. The scale is, at birth, 130 to 140 a minute; at one year, 120 to 130; at two years, 102 to 110; three years, 90 to 100; seven years, 85 to 90; fourteen years, 80 to 85; adult age, 75 to 80; first old age, 65 to 75; confirmed old age, 60 to 65.

CURIOUS ASTRONOMICAL THEORY.—We state the following on the authority of M. Arago, an eminent French astronomer: If we place in a horizontal line the series of figures of which the law is evident—

0 3 6 12 24 48 96 192

(each double the preceding,) and afterwards add 4 to each, we shall have a series denoting the relative distances of the Planets from the Sun, thus—

4	7	10	16	28	52	100	196
Mercury.	Venus.	Earth.	Mars.	*	Jupiter.	Saturn.	Uranus.

If 10 represents the distance of the Earth, 4 will be that of Mercury, 7 Venus, 16 Mars, and 52, 100, and 196, the respective distances of Jupiter, Saturn, and Uranus. This law was known as far as 100, before the discovery of Uranus: and the distance being found to correspond, affords a very remarkable confirmation of its truth. But it will be observed there is a deficiency of one term between Mars and Jupiter. This led philosophers to suspect the existence of a planet at the distance required to fill up the vacancy; and in 1801, Piazzi, of Palermo, actually discovered one, whose orbit was between those of Mars and Jupiter, and nearly at the proportional distance of 28 from the Sun. This planet was named Ceres; and since that period three others have been found —Pallas, Juno, and Vesta—all of which have their orbits so near each other as to lead astronomers to believe that these are the fragments of a larger planet, which had been shattered into pieces by some internal explosion, or the shock of a comet.—[London paper.]

SIR JOHN HERSCHEL.—In a recent sitting of the Academy of Sciences, the gold medal, value 650 fr. bequeathed by Lalande, was adjudged to Mr. (Sir John) Herschel, for his discoveries relative to double stars.—[Moniteur.]

ENTOMOLOGY.—An Entomological Society, organised during the summer, held its first meeting last month in Bond Street. The butterflies belonging to that quarter will therefore do well to beware. Mr. Children, Mr. Kirby, Mr. Spence, and some of the best pinners of the day, are members.—[London paper.]

METEOROLOGICAL RECORD, KEPT AT AVOYLLE FERRY, RED RIVER, LOU.

For the month of February, 1834—(*Lat.* 31.10 *N.*, *Long.* 91.59 *W. nearly.*)

Date.	*Thermometer.*			*Wind.*	*Weather, Remarks, &c.*
1834.	Morn'g.	Noon.	Night.		
Feb'ry 1	32	54	50	calm	clear—white frost—clear all day and night—Red River rising
" 2	31	57	54	"	" " " " " "
" 3	38	66	60	"	" " light " " " "
" 4	41	70	58	"	" —clear all day and night
" 5	46	74	61	"	" " "
" 6	50	74	43	"	" " "
" 7	51	72	68	"	" " "
" 8	60	72	69	"	" —cl'dy morn. " "
" 9	54	66	63	"	" " "
" 10	47	74	68	"	" " "
" 11	50	73	64	"	" " "
" 12	50	77	71	"	" " "
" 13	50	76	70	s—light	" " "
" 14	53	75	72	s—high	cloudy morning—clear day—cloudy morning
" 15	60	51	51	w	" all day
" 16	48	51	50	calm	" " —night clear
" 17	42	68	61	"	clear—white frost, (*light*)
" 18	48	66	63	"	" —cloudy night
" 19	61	66	66	"	cloudy—foggy morning—thunder and rain all day and night
" 20	68	74	74	"	" all day
" 21	70	78	74	s—light	" " —martin birds appeared this evening
" 22	70	78	75	"	" " —lettuce fine and large
" 23	70	74	73	"	" —showers all day and night
" 24	71	76	66	"	" —evening wind N
" 25	52	54	46	N—high	" all day and light showers
" 26	42	45	45	N—light	" and light showers
" 27	44	46	45	calm	" —rain all day
" 28	45	53	49	"	" —night clear

Red River rose this month 2 feet 3 inches—below high water, 5 feet 6 inches.

THE *Mechanics' Magazine and Register of Inventions and Improvements* is published by the Proprietors, D. K. MINOR and J. E. CHALLIS, at No. 35 Wall street, New-York: in *weekly* sheets of 16 pages, at 6¼ cents—in monthly parts of 64 pages, at 31¼ cents—in volumes of 384 pages, in cloth boards, at $1.75—or at $3 per annum *in advance.*—JOHN KNIGHT, (formerly proprietor of the London Mechanics' Magazine,) Editor.